

PICO Update

Platform and Instrumentation for Continuous Observations

PICO is a concept for making global ocean surface and subsurface observations in an unprecedented cost and operationally effective manner.

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Pacific Marine Environmental Laboratory
NOAA/PMEL
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Topics:

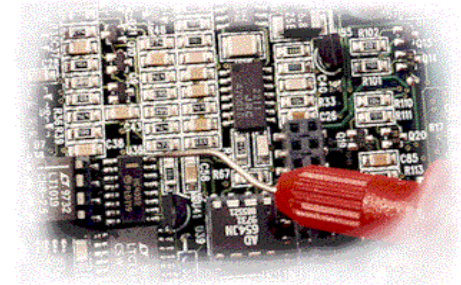
- Background
- System Components
- Performance/Field Tests
- Future Work



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NOAA-PMEL Engineering Development Division



Mission:

To support the PMEL research effort with innovations in the fields of digital and analog electronics, mechanics, materials, and software engineering.

- Staff of 19:
 - 6 engineers, 8 technicians, 5 machinists
- Facilities include:
 - Electronic labs, machine shop, mooring shop, 3ea pressure vessels (85 MPa), 12m workboat *S.P. HAYES*, dynamic line tester and wind tunnel
- FY '05 Support
 - 30 cruises on 11 different ships; 260 DAS
 - Over 180 moorings deployed, 48ea 40' containers shipped



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Do We Need PICO?

- Present methodologies for deploying surface moorings in deep water preclude answering needs as outlined in the Final Report from the [U.S. Ocean Commission](#) and the [NSF Committee on Ocean Sciences at the New Millennium](#) and other documents that advocated “sustained” observations on a global scale.



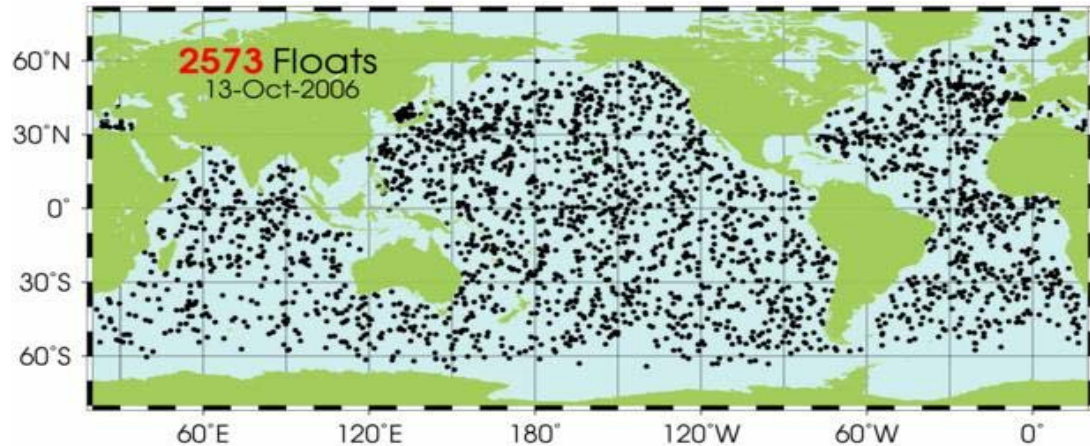
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The Global Ocean

Each float costs about \$15,000 and this cost about doubles when the cost of analyzing the data and running the project is taken into account. The array will eventually have 3000 floats and to maintain the array will need 800 floats to be deployed each year. Thus the approximate cost of the project is $800 \times \$30,000 = \24M per year.

- Climate change? Better look at the water.
- Few long term time series stations
- PICO and ARGO



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Experience is a great teacher

PMEL has developed, deployed, and maintained the largest moored observing array (TAO), the tsunami warning array (DART) and other many other moorings.

PICO design goals reflect some of the knowledge gained:



○ Simplified deployments
(minimize ship requirements)



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PMEL Observation System Experience

← 10 Years →

Project	Science & Engr Planning	Experimental Design	Prototype Development	Implementation	Operations	Science Products	NOAA Relevance
ENSO	X	X	X	X	X	X	Climate Obs & Analysis
Global Carbon Cycle	X	X	X	Underway		X	Climate Obs & Analysis
North Pacific Climate/Fisheries	X	X	Underway			X	Climate & Ecosystems
Tsunami	X	X	X	X	X	X	Weather & Water Tsunami
Fisheries Oceanography	X	X	X	Underway	Underway	X	Ecosystems Observations
Seafloor Processes	X	X	X	Underway	Underway	X	Ecosystem Research
Acoustic Monitoring	X	X	X	Underway	Underway	X	Ecosystems Research



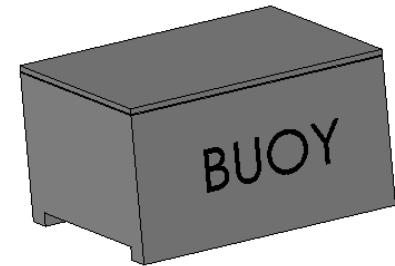
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Buoy in a Box?

The engineering challenges to build a system to address the PICO goal but has the function capabilities of an TAO Buoy are many.

- Mooring line *(One piece - vendor participation)*
- Sensors *(Small systems need small sensors)*
- Buoy *(Cheap, difficult to harm)*
- Anchor *(Multi-purpose throw away part)*
- Handling *(Keep it simple)*

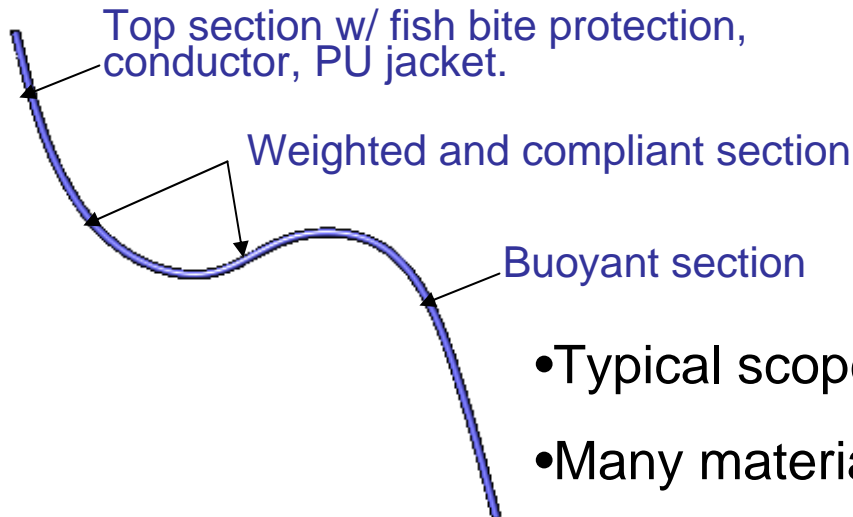


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Mooring Line

- A typical deep water mooring uses 6 to 8 reels of line (and bad backs).
- PICO line is one continuous piece from the vendor with several functional elements.



- Typical scope = 1.15
- Many material options



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Anchor Design

- Anchor to serve as a buoy stand and a reel storage device.
- Payout >5000 m of line with no fouling.
- Made with few parts commensurate with the one time use factor.
- 9 deep water deployments have proven the concept viable.

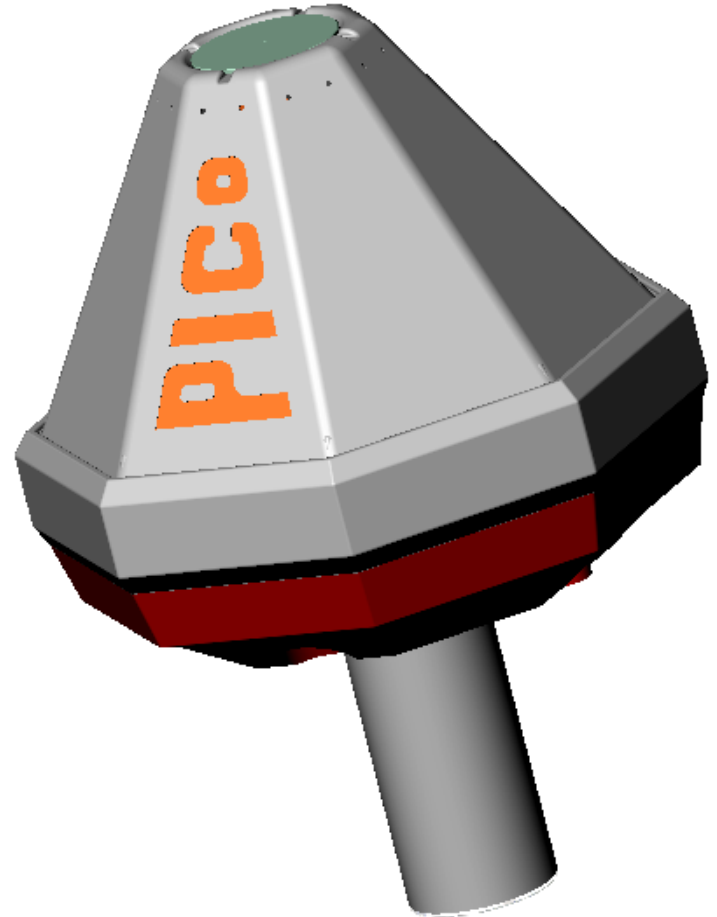


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Buoy Hull

- Simple - galvanized steel, foam, fiberglass, polyurea
- Small – 1020 kg disp, 1.3m dia.
- Integral instrument well
- Tough and compliant construction
- Bridle / sensor garage
- Few fasteners
- Low radar return



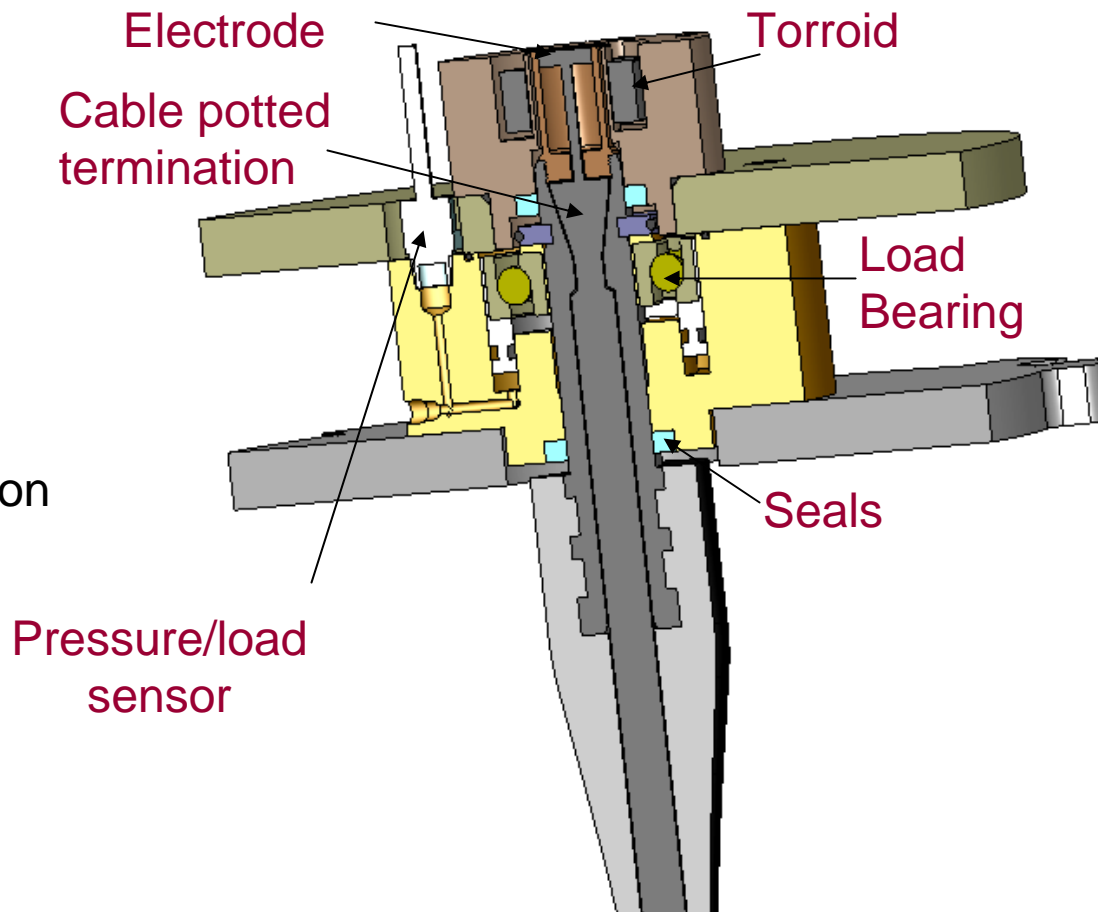
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PICO Terminator

The Terminator is a critical element with several functions:

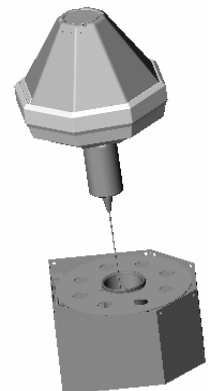
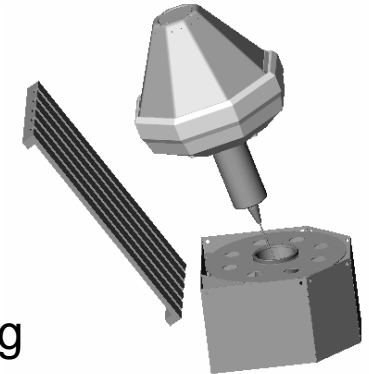
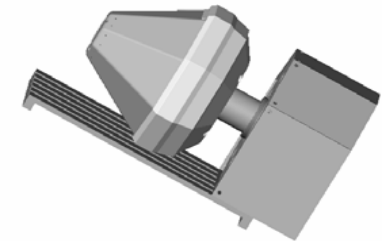
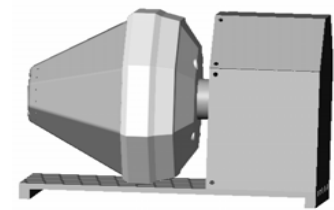
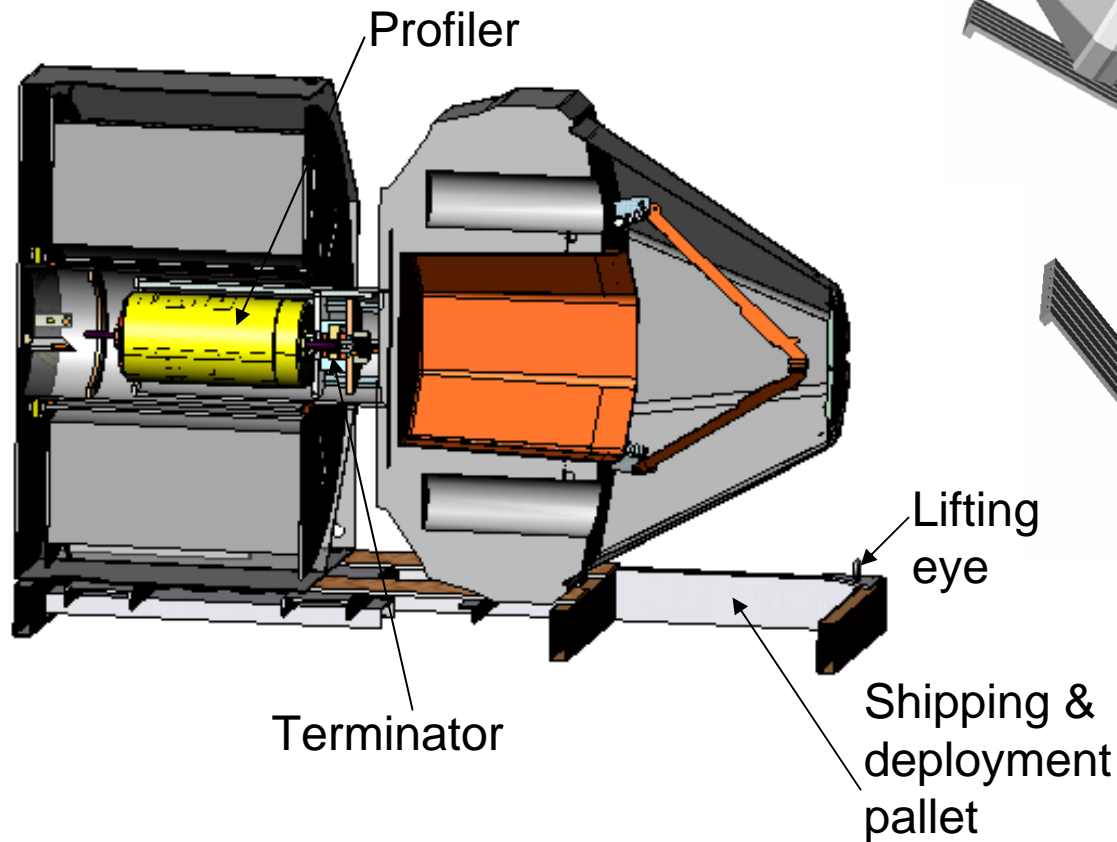
- Line termination
- Swivel
- Inductive data connection
- Load Cell



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Palletized PICO



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PICO Profiler

- Profiler will move up and down the mooring line measuring, at least, temperature, conductivity and depth.
- Must have a long life (power efficient, energy harvesting, stable sensors)
- New concepts needed, but ideas are drawn from others: BIO Seahorse, WHOI/McLane Profiler, WireWalker, etc.

Science drivers:

- Depth must be from near the surface to >400 meters
 - Frequency of profiles – as often as possible
 - Capability for additional sensors (currents, chlorophyll, etc)
- Baby steps at PMEL to get there: Prototypes... The real thing?



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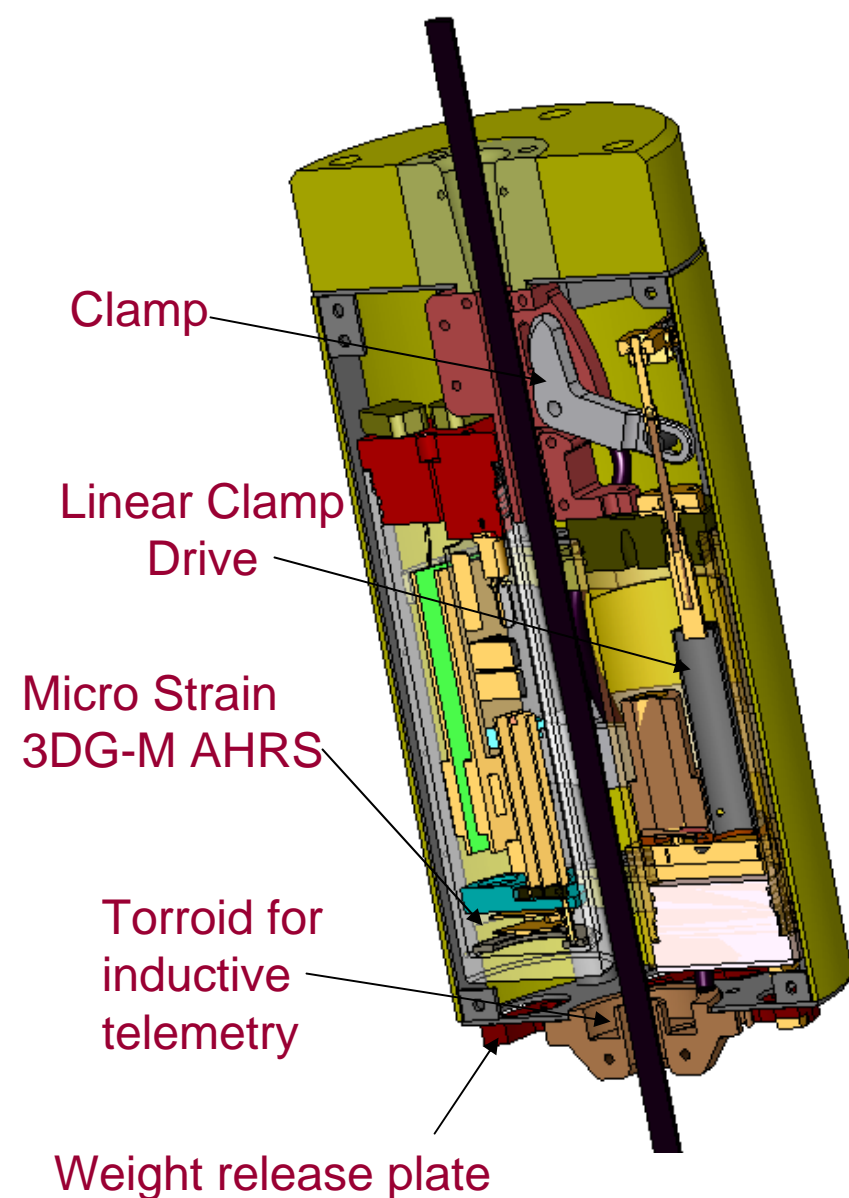
PICO 'Mule'

PURPOSE:

- Evaluate Launch issues
- Test inductive bi-directional comms
- Measure mooring dynamics
- Test profiler motion on line

CAPABILITIES:

- One round trip - with stops
- AHRS sampling at 75 Hz
- Desktop commands via Iridium and inductive comms
- Recall to surface by weight drop



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PICO Mule Sensor

3DM-G Specifications

- Sensor Range Gyros: +/-300 degrees/second FS (full scale)
- Accelerometers: +/- 2 G's FS
- Magnetometers: +/-1 Gauss FS
- Orientation Angle Resolution <0.1 degrees
- Angular Velocity Range +/-300 degrees/second (max)
- A/D Resolution 12 bits
- Output data rate 75 Hz



SBE Inductive Modem

- Data rate 1200 baud

Iridium Modem

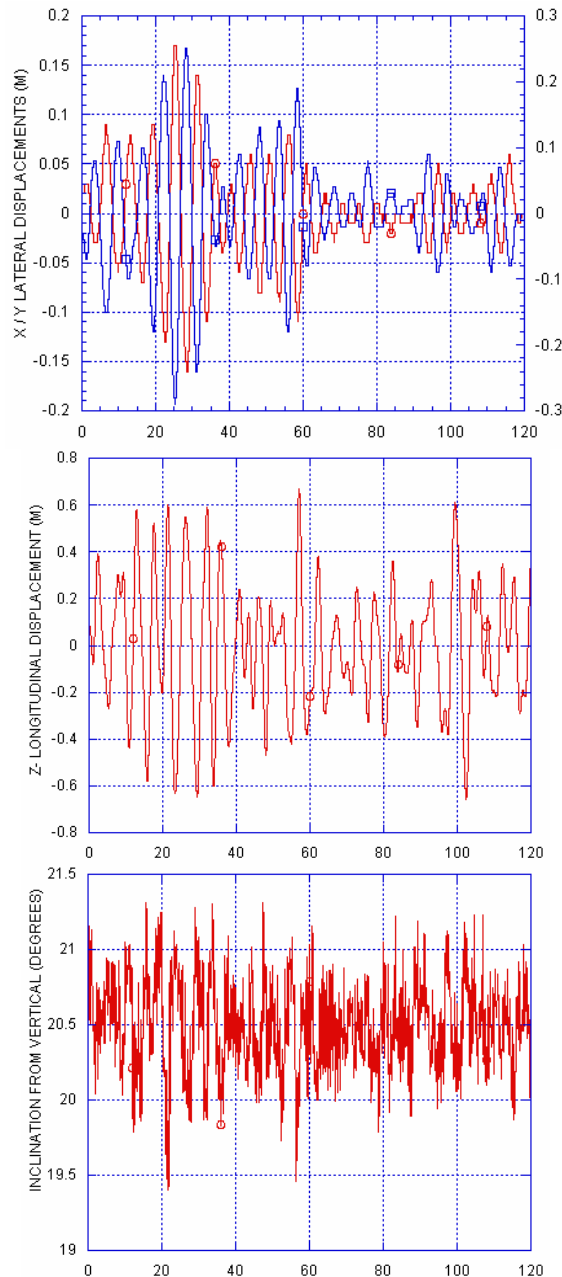
- Data rate 2400 baud



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Profiler Data



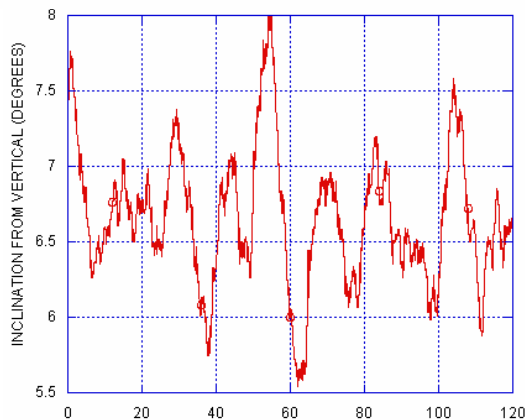
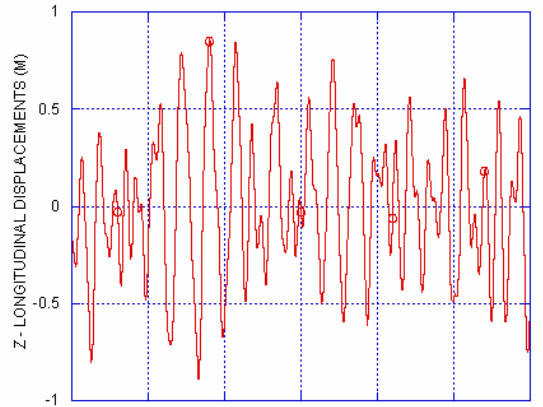
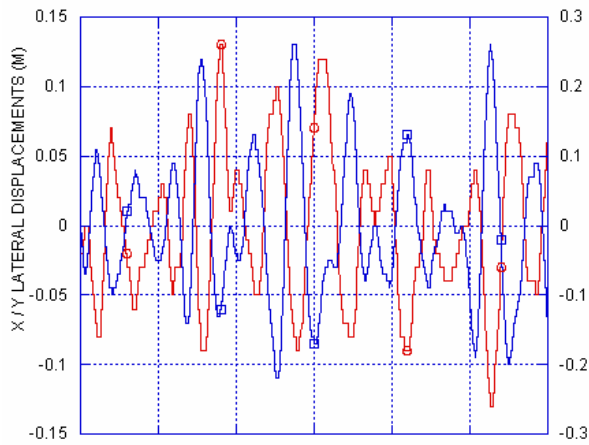
- Clamped at 397 meters depth
- Each data ensemble had 9000 points
- Nearby NDBC data buoy reported significant wave height ~ 1.0 m.
- WHOI Cable model predicted inclination at 400 m to be 22°

STATISTICS

	<u>Mean</u>	<u>Std Dev</u>	<u>Min</u>	<u>Max</u>
Tilt	20.9	00.5	19.4	22.3
Z Disp	0.21	0.13	0.00	0.81
Period	5.2		2.0	7.0

Profiler Data

- Mule 'clamped' at 460 meters depth
- Each data ensemble had 9000 points



STATISTICS

	<u>Mean</u>	<u>Std Dev</u>	<u>Min</u>	<u>Max</u>
Tilt	6.7	0.5	5.5	8.6
Z Disp	0.23	0.13	0.00	0.65
Period	5.7		3.4	9.1

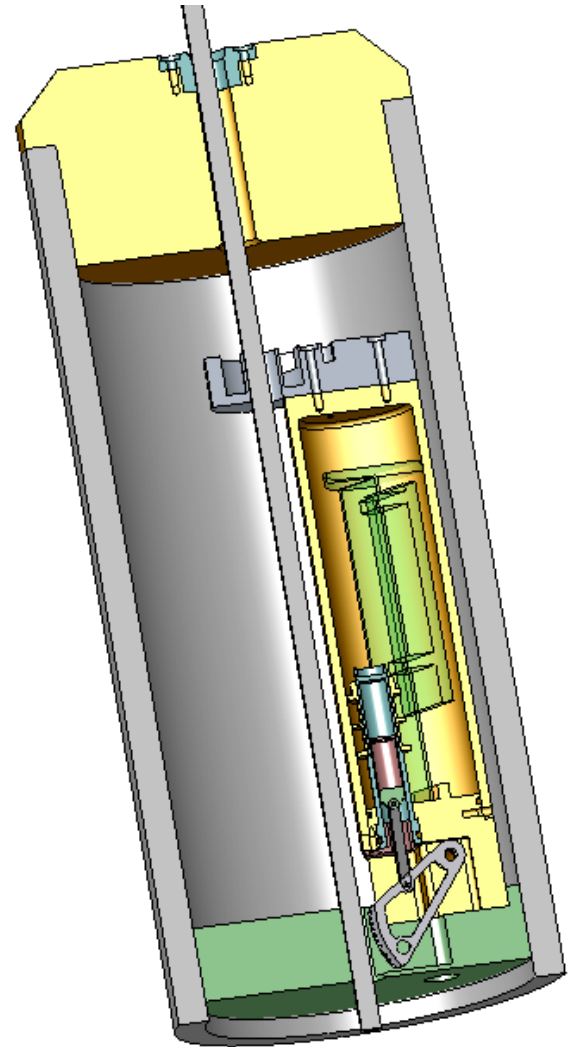
Profiler II

PURPOSE:

- Test a simple ascender concept for climbing the mooring line:
- Develop an efficient magnetic 'actuator'
- Develop and test software routines.
- Quantify ascent and descent under measured surface displacements.

FIELD TRIALS:

- Terminal fall velocity set at 1 m/sec
- Worked well in a 10 m tank with manual wave input.
- Best opportunity had negligible ship displacement but we achieved ~85% efficiency.



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PICO Deployments

- Ten PICO systems have been deployed in deep water without incident.
- Significantly, one was deployed successfully from a ship with NO PMEL personnel or mooring experience, in the middle of the night, in 4700 meters of water.
- Several failures have occurred in the top termination – epoxy potted polyester in a strain relief boot.



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What's Next?

Significant engineering challenges remain to bring the PICO concept into operational status:

- Continue to demonstrate the viability of the concept (deployments)
- Mooring line design, testing and termination refinement (modeling)
- Profiler development (draw on the small steps taken)
- Sensor integration / development (CTD, Wind, AT/RH, currents, others)
- Alternate deployment methodologies and platforms (packaging, ships of opportunity, airplanes, etc.)
- High latitude demonstration
- Collaborators and Partners
- Cost reduction (continue to minimize parts and pieces, simplify fabrication)
- Future funding and applications

For more information, see: <http://www.pmel.noaa.gov/pico/>



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Thanks...

- We appreciate the support of our sponsors:
 - NOAA/Office of Climate Observations
 - Director PMEL

...Questions?



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